

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

0475-0204P

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

10/049665

INTERNATIONAL APPLICATION NO.

PCT/EP00/07992

INTERNATIONAL FILING DATE

August 16, 2000

PRIORITY DATE CLAIMED

August 16, 1999

TITLE OF INVENTION

METHOD FOR PRODUCING A DENTAL PROSTHESIS

APPLICANT(S) FOR DO/EO/US

FRANK, Sybille; HAUPTMANN, Holger; HOSCHELER, Stefan; SCHNAGL, Robert; SUTTOR, Daniel

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☒ has been transmitted by the International Bureau. WO 01/12097
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
 - a. ☒ is transmitted herewith.
 - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4)
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 20. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98, Form PTO-1449(s), and International Search Report (PCT/ISA/210) with 9 cited document(s).
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:
 - 1.) Certified copy of English translation
 - 2.) Zero (0) sheets of Formal Drawings

ATTORNEY'S DOCKET NUMBER

PCT/EP00/07992

0475-0204P

21. ☒ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):

Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
and International Search Report not prepared by the EPO or JPO. **\$1,040.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	\$890.00
---	-----------------

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO.	\$740.00
---	-----------------

International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	\$710.00
--	-----------------

International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4).....	\$100.00
---	-----------------

ENTER APPROPRIATE BASIC FEE AMOUNT =

CALCULATIONS

\$ 890.00

\$ 130.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
--------	--------------	--------------	------

Total Claims	22 - 20 =	2	X \$18.0
--------------	-----------	---	----------

Independent Claims	3 - 3 =	0	Y \$84.0
--------------------	---------	---	----------

MULTIPLE DEPENDENT CLAIM(S) (if applicable)	Yes	\$380.00
---	-----	----------

ADDITIONAL DEPENDENT CLAIM(S) (if applicable)	Yes	+ \$280.00
TOTAL OF ABOVE PAY CATEGORIES		

TOTAL OF ABOVE CALCULATIONS

☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.

Reduced by 1/2.

Processing fee of \$130.00 for furnishing the English translation later than ☐ 30 ☐ 60 ☐ 90 ☐ 120 ☐ 150 ☐ 180 ☐ 210 ☐ 240 ☐ 270 ☐ 300 ☐ 330 ☐ 360 ☐ 390 ☐ 420 ☐ 450 ☐ 480 ☐ 510 ☐ 540 ☐ 570 ☐ 600 ☐ 630 ☐ 660 ☐ 690 ☐ 720 ☐ 750 ☐ 780 ☐ 810 ☐ 840 ☐ 870 ☐ 900 ☐ 930 ☐ 960 ☐ 990 ☐ 1020 ☐ 1050 ☐ 1080 ☐ 1110 ☐ 1140 ☐ 1170 ☐ 1200 ☐ 1230 ☐ 1260 ☐ 1290 ☐ 1320 ☐ 1350 ☐ 1380 ☐ 1410 ☐ 1440 ☐ 1470 ☐ 1500 ☐ 1530 ☐ 1560 ☐ 1590 ☐ 1620 ☐ 1650 ☐ 1680 ☐ 1710 ☐ 1740 ☐ 1770 ☐ 1800 ☐ 1830 ☐ 1860 ☐ 1890 ☐ 1920 ☐ 1950 ☐ 1980 ☐ 2010 ☐ 2040 ☐ 2070 ☐ 2100 ☐ 2130 ☐ 2160 ☐ 2190 ☐ 2220 ☐ 2250 ☐ 2280 ☐ 2310 ☐ 2340 ☐ 2370 ☐ 2400 ☐ 2430 ☐ 2460 ☐ 2490 ☐ 2520 ☐ 2550 ☐ 2580 ☐ 2610 ☐ 2640 ☐ 2670 ☐ 2700 ☐ 2730 ☐ 2760 ☐ 2790 ☐ 2820 ☐ 2850 ☐ 2880 ☐ 2910 ☐ 2940 ☐ 2970 ☐ 3000 ☐ 3030 ☐ 3060 ☐ 3090 ☐ 3120 ☐ 3150 ☐ 3180 ☐ 3210 ☐ 3240 ☐ 3270 ☐ 3300 ☐ 3330 ☐ 3360 ☐ 3390 ☐ 3420 ☐ 3450 ☐ 3480 ☐ 3510 ☐ 3540 ☐ 3570 ☐ 3600 ☐ 3630 ☐ 3660 ☐ 3690 ☐ 3720 ☐ 3750 ☐ 3780 ☐ 3810 ☐ 3840 ☐ 3870 ☐ 3900 ☐ 3930 ☐ 3960 ☐ 3990 ☐ 4020 ☐ 4050 ☐ 4080 ☐ 4110 ☐ 4140 ☐ 4170 ☐ 4200 ☐ 4230 ☐ 4260 ☐ 4290 ☐ 4320 ☐ 4350 ☐ 4380 ☐ 4410 ☐ 4440 ☐ 4470 ☐ 4500 ☐ 4530 ☐ 4560 ☐ 4590 ☐ 4620 ☐ 4650 ☐ 4680 ☐ 4710 ☐ 4740 ☐ 4770 ☐ 4800 ☐ 4830 ☐ 4860 ☐ 4890 ☐ 4920 ☐ 4950 ☐ 4980 ☐ 5010 ☐ 5040 ☐ 5070 ☐ 5100 ☐ 5130 ☐ 5160 ☐ 5190 ☐ 5220 ☐ 5250 ☐ 5280 ☐ 5310 ☐ 5340 ☐ 5370 ☐ 5400 ☐ 5430 ☐ 5460 ☐ 5490 ☐ 5520 ☐ 5550 ☐ 5580 ☐ 5610 ☐ 5640 ☐ 5670 ☐ 5700 ☐ 5730 ☐ 5760 ☐ 5790 ☐ 5820 ☐ 5850 ☐ 5880 ☐ 5910 ☐ 5940 ☐ 5970 ☐ 6000 ☐ 6030 ☐ 6060 ☐ 6090 ☐ 6120 ☐ 6150 ☐ 6180 ☐ 6210 ☐ 6240 ☐ 6270 ☐ 6300 ☐ 6330 ☐ 6360 ☐ 6390 ☐ 6420 ☐ 6450 ☐ 6480 ☐ 6510 ☐ 6540 ☐ 6570 ☐ 6600 ☐ 6630 ☐ 6660 ☐ 6690 ☐ 6720 ☐ 6750 ☐ 6780 ☐ 6810 ☐ 6840 ☐ 6870 ☐ 6900 ☐ 6930 ☐ 6960 ☐ 6990 ☐ 7020 ☐ 7050 ☐ 7080 ☐ 7110 ☐ 7140 ☐ 7170 ☐ 7200 ☐ 7230 ☐ 7260 ☐ 7290 ☐ 7320 ☐ 7350 ☐ 7380 ☐ 7410 ☐ 7440 ☐ 7470 ☐ 7500 ☐ 7530 ☐ 7560 ☐ 7590 ☐ 7620 ☐ 7650 ☐ 7680 ☐ 7710 ☐ 7740 ☐ 7770 ☐ 7800 ☐ 7830 ☐ 7860 ☐ 7890 ☐ 7920 ☐ 7950 ☐ 7980 ☐ 8010 ☐ 8040 ☐ 8070 ☐ 8100 ☐ 8130 ☐ 8160 ☐ 8190 ☐ 8220 ☐ 8250 ☐ 8280 ☐ 8310 ☐ 8340 ☐ 8370 ☐ 8400 ☐ 8430 ☐ 8460 ☐ 8490 ☐ 8520 ☐ 8550 ☐ 8580 ☐ 8610 ☐ 8640 ☐ 8670 ☐ 8700 ☐ 8730 ☐ 8760 ☐ 8790 ☐ 8820 ☐ 8850 ☐ 8880 ☐ 8910 ☐ 8940 ☐ 8970 ☐ 9000 ☐ 9030 ☐ 9060 ☐ 9090 ☐ 9120 ☐ 9150 ☐ 9180 ☐ 9210 ☐ 9240 ☐ 9270 ☐ 9300 ☐ 9330 ☐ 9360 ☐ 9390 ☐ 9420 ☐ 9450 ☐ 9480 ☐ 9510 ☐ 9540 ☐ 9570 ☐ 9600 ☐ 9630 ☐ 9660 ☐ 9690 ☐ 9720 ☐ 9750 ☐ 9780 ☐ 9810 ☐ 9840 ☐ 9870 ☐ 9900 ☐ 9930 ☐ 9960 ☐ 9990 ☐ 10020 ☐ 10050 ☐ 10080 ☐ 10110 ☐ 10140 ☐ 10170 ☐ 10200 ☐ 10230 ☐ 10260 ☐ 10290 ☐ 10320 ☐ 10350 ☐ 10380 ☐ 10410 ☐ 10440 ☐ 10470 ☐ 10500 ☐ 10530 ☐ 10560 ☐ 10590 ☐ 10620 ☐ 10650 ☐ 10680 ☐ 10710 ☐ 10740 ☐ 10770 ☐ 10800 ☐ 10830 ☐ 10860 ☐ 10890 ☐ 10920 ☐ 10950 ☐ 10980 ☐ 11010 ☐ 11040 ☐ 11070 ☐ 11100

months from the earliest claimed priority date (37 CFR 1.492(f))

TOTAL NATIONAL FEE

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be

accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **\$40.00** per property +

TOTAL FEES ENCLOSED

Amount to be:	\$
---------------	----

refunded	\$
----------	----

charged	\$
---------	----

- a. ☒ A check in the amount of \$ 1336.00 to cover the above fees is enclosed.
- b. ☐ Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.
- c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-2448.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

Send all correspondence to:

Birch, Stewart, Kolasch & Birch, LLP or Customer No. 2292

P.O. Box 747

Falls Church, VA 22040-0747

(703) 205-8000

Date: February 15, 2002

By Andrew D. Meikle, #32,868

PATENT
0475-0204P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: FRANK, Sybille et al.
Int'l. Appl. No.: PCT/EP00/07992
Appl. No.: New Group:
Filed: February 15, 2002 Examiner:
For: METHOD FOR PRODUCING A DENTAL
PROSTHESIS

PRELIMINARY AMENDMENT**BOX PATENT APPLICATION**

Assistant Commissioner for Patents
Washington, DC 20231

February 15, 2002

Sir:

The following Preliminary Amendments and Remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTSIN THE SPECIFICATION:

Please amend the specification as follows:

Before line 1, insert --This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/EP00/07992 which has an International filing date of August 16, 2000, which designated the United States of America.--

IN THE CLAIMS:

Please amend the claims as follows:

4. (Amended) Process according to claim 1, the blank being processed from the side in contact with the tooth stump and from the side not in contact with the tooth stump.

5. (Amended) Process according to claim 1, the pre-sintered blank comprising zirconium oxide or aluminum oxide ceramic.

6. (Amended) Denture part which can be prepared according to a process according to claim 1.

11. (Amended) Pre-sintered blank according to claim 7, obtained by sintering at a temperature of 850 °C to 1000 °C.

12. (Amended) Pre-sintered blank according to claim 7, having a deviation from the linearity of the shrinkage per spatial direction below 0.05%.

14. (Amended) Process for the preparation of dentures according to claim 1, a blank according to claim 7 being processed by milling into a shrinkage-matched, enlarged model of the end dentures and densely sintered to its end dimensions.

15. (Amended) Process for the preparation of dentures according to claim 1, a blank according to claim 7 being processed by CAD/CAM processed to a shrinkage-matched, enlarged model of the end dentures and densely sintered to its end dimensions.

16. (Amended) Process according to claim 14, the pre-sintered blank being aesthetically re-processed after the processing and densely sintered to its end dimensions.

REMARKS

The specification has been amended to provide a cross-reference to the previously filed International Application.

The claims have been amended to delete improper multiple dependencies and to place the application into better form for examination. Entry of the above amendments is earnestly solicited. An early and favorable first action on the merits is earnestly solicited.

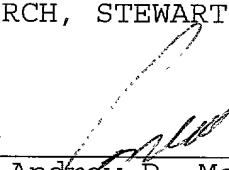
Attached hereto is a marked-up version of the changes made to the application by this Amendment.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By


Andrew D. Meikle, #32,868

ADM/cqc
0475-0204P

P.O. Box 747
Falls Church, VA 22040-0747
(703) 205-8000

Attachment: VERSION WITH MARKINGS TO SHOW CHANGES MADE

VERSION WITH MARKINGS TO SHOW CHANGES MADE

The claims have been amended as follows:

4. (Amended) Process according to [one of the previous claims]claim 1, the blank being processed from the side in contact with the tooth stump and from the side not in contact with the tooth stump.

5. (Amended) Process according to [one of the previous claims]claim 1, the pre-sintered blank comprising zirconium oxide or aluminum oxide ceramic.

6. (Amended) Denture part which can be prepared according to a process according to [one of claims 1 to 5]claim 1.

11. (Amended) Pre-sintered blank according to [one of claims 7 to 10]claim 7, obtained by sintering at a temperature of 850 °C to 1000 °C.

12. (Amended) Pre-sintered blank according to [one of claims 7 to 11]claim 7, having a deviation from the linearity of the shrinkage per spatial direction below 0.05%.

14. (Amended) Process for the preparation of dentures according to [one of claims 1 to 5]claim 1, a blank according to

[one of claims 7 to 12]claim 7 being processed by milling into a shrinkage-matched, enlarged model of the end dentures and densely sintered to its end dimensions.

15. (Amended) Process for the preparation of dentures according to [one of claims 1 to 5]claim 1, a blank according to [one of claims 7 to 12]claim 7 being processed by CAD/CAM processed to a shrinkage-matched, enlarged model of the end dentures and densely sintered to its end dimensions.

16. (Amended) Process according to claim 14[or 15], the pre-sintered blank being aesthetically re-processed after the processing and densely sintered to its end dimensions.

(Rev. 11/13/01)

Process for the preparation of dentures

The invention relates to a process for the preparation of dentures. Furthermore the invention relates to pre-sintered blanks of zirconium oxide ceramic which have a raw breaking resistance in a selected range.

Ceramic dentures are normally prepared by grinding of densely sintered ceramic blanks.

Thus in EP-B-O 160 797 for example a blank and its use for the preparation of dental shaped parts using a grinding tool is described. Furthermore a process for the preparation of ceramic dental prostheses is known from EP-A-O 630 622 in which a blank of a certain composition is ground using a rotating tool.

A disadvantage of the processing of densely sintered blanks is in particular their high hardness which leads to long processing times and high wear of tools. The costs of the processing of these blanks are thereby very high.

A disadvantage of grinding processes for the processing or preparation of ceramic dentures is furthermore that a high-precision shape of the ground blanks cannot be ensured due to the lack of defined cutting edges.

The processing of blanks pre-sintered to a certain degree of hardness is mentioned in principle in EP-A-O 630 622 on page 3, column 3, lines 13 ff., but the processing of the blanks by grinding processes is retained.

Pre-sintered blanks have a lower hardness than those which are densely sintered and show a higher hardness than those which are not sintered. It is therefore desirable in principle, in order to guarantee easy processing or to first make processing possible, to use pre-sintered blanks.

Thus for example the processing tools are less severely worn, which leads to longer service lives of the tools and thus to considerably reduced costs. The preparation of very fine microstructures also first becomes possible as the predictable shrinkage of the ceramic during dense sintering leads to a further
5 reduction in size of the produced microstructures. The frequent microscopic damage to the ceramic during processing can be cured in the case of pre-sintered blanks within the framework of the dense sintering process.

In order to be able to prepare dentures by processing in the non-densely sintered state, a completely homogeneous distribution of the strength and hardness and the density within each spatial direction of the ceramic blank is necessary, which in particular is also retained after the pre-sintering of the blank. It is advantageous to avoid deviations in the density and hardness distribution of the ceramic when filigree structures or multi-section bridges are to be prepared, as
10 even the slightest inhomogeneities can lead to breaking points which considerably impair the durability of these complex structures during the processing or can lead to a different sintering behaviour, behaviour which can be recognized from the distortion of the workpiece during sintering. Such a distortion leads however to poor fitting accuracy and thus to unusability of the denture.
15

For the following reasons the processing of pre-sintered blanks has up until now not led to a technical realisation:
20

The dense sintering of a pre-sintered blank after processing is associated with changes in dimensions which are difficult to calculate and can be applied to the actual milling parameters only by means of complicated processes. Thus
25 subsequent adjustments are necessary on non-accurately-fitting denture parts after dense sintering. Due to the higher hardness of the densely sintered denture parts these have to take place using removal processes and are to be evaluated as very critical, as a self-healing of injuries to the surface structures, such as
30 takes place during the dense sintering process, can no longer be made good.

In summary, there is a considerable demand for methods for the preparation of accurately-fitting dentures using pre-sintered ceramic blanks.

- 5 It is therefore the object of the invention to make available an improved process for the preparation of accurately-fitting, highly-precise dentures.

Surprisingly this object can be achieved by a process for the preparation of dentures, comprising the steps:

10

- a) preparation of a blank,
- b) processing of the blank by milling methods,
- c) dense sintering of the blank in a temperature range from 1200 to 1650°C,

15

the blank comprising a pre-sintered material and having a raw breaking resistance of 15 to 30 MPa, preferably 23 to 28 MPa.

20

By blanks is meant within the framework of this invention a non-processed material block or moulding which is subsequently passed to a shaping stage through the processing. These blanks can consist of the most varied materials, in particular ceramics.

25

By dentures are meant within the framework of this invention in particular crowns and bridges having three or more sections. The blanks according to the invention are particularly suitable for the preparation of bridges having three or more sections.

30

By processing is meant within the framework of this invention milling measures for shaping a blank, which lead to the blank being converted into a shape coming as close as possible to a natural tooth. Not meant by processing is cleaning of the blank processed in the above sense or the removal of support and holding

structures which result from the embedding of the blank in a blank holder, even if this cleaning can be carried out by milling methods.

5 The terms "comprise" and "containing" within the meaning of the present invention introduce a non-limitative list of features.

10 Customary raw breaking resistances known from the state of the art for ceramic dental blanks are in the higher strength range, for example from 75 to 110 MPa; such blanks cannot be used for the invention.

15 It was found that the processing of pre-sintered blanks, the raw breaking resistance of which lies outside the range according to the invention, does not lead to usable results. In the case of lower raw breaking resistances, the resulting blanks are too soft, and can fracture during milling, whereas in the case of higher raw breaking resistances the resulting blanks are too hard, and neither can be processed with the normal processing procedures.

20 The processing of the blanks pre-sintered according to the invention is carried out with milling methods. Very fine microstructures can be produced by the extremely sharp cutting edges of the milling tools. The cutting edges of the tool remain sharp over a long use period, as the blank in its pre-sintered state has only a low hardness and strength. During the milling of the blank the tool of the processing machine operates during rough working for example at a speed of 5,000 to 40,000 rpm, preferably 15,000 to 25,000 rpm with a feed rate of 20 to 5,000 mm/min, preferably 500 to 3,500 mm/min. The fine processing takes place for example at a speed of 5,000 to 50,000 rpm, preferably 18,000 to 35,000 rpm with a feed rate of 20 to 5,000 mm/min, preferably 500 to 3,500 mm/min. In both processing steps a milling diameter of 0.8 to 4 mm is used for example.

30 The blanks are particularly preferably processed without a supporting structure as described for example in the example of EP-A2-0 824 897. The processing

step takes place from the side of the fully processed denture part in contact with the tooth stump and from the side not in contact with the tooth stump. It is of particular advantage that the blank need not be surrounded or supported by a high-temperature investment compound during the dense sintering process.

During the course of the dense sintering process, the processed blank can be held by means of carrier devices which adapt independently to the contraction dimensions occurring during the baking process, such as are known for example from the patent application DE-199 04 534, to avoid a distortion during the sintering process.

The blanks can consist of normal dental ceramics. By dental ceramics are meant within the framework of this invention compositions which, along with the normal ceramic constituents, can also optionally contain small amounts of other constituents (additives), such as sintering auxiliaries. Data relating to formulations in the form of components and wt.-% always relates to a product which no longer contains additives. Small traces of additives, also in the pre- or post-sintered ceramics are of course also possible for kinetic, thermodynamic or chemical reasons and are therefore to be understood as also contained within the scope of protection of this invention.

In particular the presence of impurities encourages the formation of glass phases or glass. Blanks which do not form any glass phases or glass during the dense sintering are therefore preferred.

The blanks according to the invention furthermore display a preferred deviation from the linearity of the shrinkage per spatial direction which is less than 0.05 %, particularly preferably less than 0.01 %.

The blanks according to the invention preferably consist of aluminium oxide or zirconium oxide ceramic. Zirconium oxide ceramic is particularly preferred.

It is known that the strength of nonmetallic-inorganic systems in general depends on the critical stress intensity factor K_{IC} . This factor is clearly lower with amorphous materials, for example glasses, than with purely crystalline systems (D. Munz/T. Fett: Mechanisches Verhalten keramischer Werkstoffe [Mechanical Behaviour of Ceramic Materials], Springer-Verlag). Thus the strength of ceramics also decreases if amorphous phases form at the grain boundaries. The ceramics preferably usable according to the invention therefore display for example a K_{IC} value of 5 to 10, preferably 8 to 10, measured according to EN 843.

Surprisingly it was ascertained that ceramics based on zirconium oxide with a sinter addition of 0.1 to 0.50 wt.-% of at least one of the oxides of the elements aluminium, gallium, germanium, indium have a particularly favourable and uniformly distributed hardness and strength. They are therefore particularly suitable for the preparation according to the invention of complex dentures and filigree structures. It is an advantage if the oxides of the abovementioned elements are added in an amount as defined above with homogenous distribution and these are not, like say impurities, distributed non-uniformly and with varying concentration. This homogeneous distribution can be achieved for example by co-precipitation as is described in the embodiment of this invention.

In addition a uniform distribution of the particles formed during the pre-sintering process is an advantage. The granular form of the particles is preferably equiaxial with an average grain diameter less than 1 μm , particularly preferably less than 0.7 μm .

The blanks used for the invention normally have a pore volume of 50 to 65 %. The average pore size is normally in the range from 3 μm to 0.1 μm , the range preferably being from 2 μm to 0.2 μm .

In the case of this ceramic, the pre-sintering process is carried out in a preferred temperature range of 850°C to 1000°C, particularly preferably between 950°C and 995°C, in order to achieve the raw breaking resistance according to the invention. The pre-sintering process is carried out for example over a time period of 30 to 55 hours.

Such ceramic systems are known to have a tendency to shrink anisotropically, i.e. have a shrinkage which is different in the three spatial directions. As this shrinkage is linear in itself in each spatial direction, these ceramics are surprisingly extremely suitable for the preparation of extremely accurately-fitting and complex dentures.

The use of zirconium oxide ceramics in the medical field is generally known. Pure zirconium oxide cannot be used for mechanical applications as its volume changes too much through modification changes during the cooling process after sintering. Through the addition of magnesium, cerium or yttrium oxides, however, this process can be checked. A detailed discussion can be found in "Aluminium- und Zirkonoxidkeramik in der Medizin" [Aluminium and Zirconium Oxide Ceramics in Medicine], reprint from Industrie Diamanten Rundschau, IDR 2/1993 and also in EP-A-0 634 149.

The addition of 0.1 to 0.50 wt.-%, preferably 0.15 to 0.50 wt.-%, particularly preferably 0.20 to 0.50 wt.-%, quite particularly preferably 0.25 to 0.50 wt.-% of at least one of the oxides of the elements aluminium, gallium, germanium, indium to such ceramics leads to the lowering of the sintering temperature and the increasing of the stability and the hydrolytic resistance during use. This situation can also be found for aluminium oxide in "Zirconia Powder" 09/97, product information from the company Tosoh. The ceramic is however not suitable for the preparation of accurately-fitting dentures according to the present invention, as without the maintenance of the raw breaking resistance according to the

invention, milling to form highly-accurate dentures is not possible due to the previously discussed effects.

Likewise a subject of the present invention is a pre-sintered blank made from zirconium oxide ceramics of the composition (1), containing:

- (A) 91 to 98.45 wt.-%, preferably 91 to 97.25 wt.-% zirconium oxide,
- (B) 0 to 3.5 wt.-%, preferably 0 to 2.5 wt.-% hafnium oxide,
- (C) 1.5 to 6.0 wt.-%, preferably 2.5 to 6.0 wt.-% yttrium oxide,
- (D) 0.05 to 0.50 wt.-%, preferably 0.15 to 0.50 wt.-%, particularly preferably 0.20 to 0.50 wt.-%, quite particularly preferably 0.25 to 0.50 wt.-% of at least one of the oxides of the elements aluminium, gallium, germanium, indium,
- (E) 0 to 1.9 wt.-%, preferably 0.0005 to 1.5 wt.-% coloring additives,

the wt.-% having to add up to 100 and the blank having a raw breaking resistance of 15 to 30 MPa, preferably 23 to 28 MPa.

By component (E) of the composition (1) are meant coloring oxides from elements of the group Pr, Er, Fe, Co, Ni, Ti, V, Cr, Cu, Mn, with Fe_2O_3 , Er_2O_3 or MnO_2 preferably being used.

A further subject of the invention is a process for the preparation of ceramic dentures, a blank of the composition (1) being processed by suitable processing measures into a shrinkage-matched enlarged model of the end denture and then densely sintered to its end dimensions. By shrinkage-matched model is meant a model of the desired denture enlarged according to part of the theoretically expected shrinkage.

The composition (1) according to the invention is industrially prepared by dissolving the components (A) and (B) of the composition (1) contained in

commercially available zirconium sand with HCl, mechanically separating the low-soluble impurities and combining them with the additives (C) and (D) likewise present as oxichlorides or chlorides after treatment with HCl as an aqueous, strongly acid solution.

5

Additives according to component (E) acting as colorants are then added likewise as chlorides, obtained through dissolution in HCl.

10

There follows a co-precipitation of the dissolved components by hydrolysis, calcination of the precipitation product, grinding of the calcinate to the desired end fineness and also a spray-drying process using temporary slip and binding agents.

15

The thus-obtained granules can be converted into the desired preform with known compression processes. These compressed blanks are separated by a binder-dependent heat treatment and pre-sintered at a temperature between 850°C and 1000°C, preferably between 950°C and 995°C, for example with 0.5 to 4 h holding time.

20

Ceramic powders containing the components (A) to (D) are also commercially available (Tosoh, Tokyo, Japan).

25

The blanks processed with customary processes, for example CAD/CAM or copy-milling, are densely sintered at 1200°C to 1650°C, particularly preferably 1350°C to 1550°C, for example with 1 to 3 h holding time.

30

Preferably before the dense sintering, aesthetic measures such as individual coloring can be carried out. Usable are for example processes according to the patent application DE-199 04 522, the use of ionic solutions of at least one of the salts of the rare earth elements, of the lanthanides or the elements of the group Fe, Co, Ni, Ti, V, Cr, Cu, Mn being preferred.

Optionally, after dense sintering, the ceramic blanks processed to form a dental prosthesis are removed from a blank-holding device, a holding device from the utility model DE-298 154 86 for example being able to be used during
5 processing. After the removal from a blank-holding device, the blank can optionally be re-processed for the purpose of removing holding pins or connection points between the blank-holding device and the processed blank.

Furthermore, the blank can be faced using customary measures. For this
10 purpose, a facing compound which has the same coefficient of thermal expansion as the blank can be burned onto the blank. Blanks which are suitable for the present invention can for example have a coefficient of thermal expansion between 9.0 and 10.5 ppm/K, preferably between 9.4 and 9.8 ppm/K.

15 The invention is explained in more detail in the following by means of examples without thereby being limited in any way.

Strength data, in particular breaking resistances within the framework of these statements, relate to the "piston-on-three-ball test" according to ISO 6872.
20

To prepare the blanks according to the invention, preforms obtained while applying pressure are taken as a basis. When preparing these preforms, examples of starting materials are pure chlorides, oxichlorides or nitrates, chlorides being used in the examples.
25

Preparation examples 1 and 2

Zirconium oxide ceramic containing aluminium oxide

To obtain approx. 200 g of ready doped compressed granules, the components
5 are dissolved in distilled water according to the following table:

No.	M(ZrCl ₄) [g]	M(YCl ₃ ·6H ₂ O) [g]	M(AlCl ₃) [g]	M(FeCl ₃) [g]	M(ErCl ₃) [g]
1 [coloured] (% as oxide)	355.6 (94.0)	33.4 (5.17)	0.65 (0.25)	0.77 (0.2)	0.29 (0.38)
2 [uncoloured] (% as oxide)	357.66 (94.55)	33.36 (5.20)	0.65 (0.25)	0	0
Component	(A)	(C)	(D)	(E)	(E)

There follows a co-precipitation of the dissolved components by hydrolysis, the
aforementioned solution being reacted with 32 l 6-molar aqueous NH₄OH
10 solution. An at least 30-times excess of OH⁻ concentration relative to the
stoichiometric requirement is recommended. The precipitation product must then
be washed free of Cl⁻. The calcination of the precipitation product is carried out at
700°C over 0.75 hours, followed by a grinding of the calcinate to an end fineness
of D₅₀ = 0.6 µm and also by a spray-drying process using temporary slip and
15 binding agents (here: 2.0 wt.-% PVA, 0.15 wt.-% oleic acid relative to oxide).

Using an isostatic press, for example at 1500 to 2500, preferably 1700 to 2200
bar, the granules obtained are made into preforms measuring d = 31 mm and l =
150 mm.

The preforms are released from the binder by a heat treatment (heating rate: 4
K/min to 650°C, 1 hour holding time) and pre-sintered at a temperature of 970°

with 0.5 hours holding time to produce the blanks that can be used according to the invention.

Process examples

To prepare accurately-fitting bridges, blanks prepared according to the preparation examples 1 and/or 2 are worked with a CAD/CAM system by milling and densely sintered under the following parameters:

5

Heating rate: 10 K/min to end temperature: 1500°C

Holding time at end temperature: 2 h

10

The result is in both cases extremely accurately-fitting dentures with a high strength ($\sigma > 1000$ MPa).

Patent claims

1. Process for the preparation of dentures, comprising the steps:
 - a) preparation of a blank,
 - b) processing of the blank by milling methods,
 - c) dense sintering of the blank in a temperature range from 1200 to 1650°C,the blank comprising a pre-sintered material and having a raw breaking resistance from 15 to 28 MPa.
2. Process according to claim 1, the blank having a raw breaking resistance of 23 to 28 MPa.
3. Process according to one of claims 1 or 2, in which, during the milling of the blank, the tool of the processing machine operates at a speed of 5,000 to 40,000 rpm and a feed rate of 20 to 5,000 mm/min during the rough processing and a speed of 5,000 to 50,000 rpm and a feed rate of 20 to 5,000 mm/min during fine processing and in each case with a milling diameter of 0.8 to 4 mm.
4. Process according to one of the previous claims, the blank being processed from the side in contact with the tooth stump and from the side not in contact with the tooth stump.
5. Process according to one of the previous claims, the pre-sintered blank comprising zirconium oxide or aluminium oxide ceramic.
6. Denture part which can be prepared according to a process according to one of claims 1 to 5.
7. Pre-sintered blank made from zirconium oxide ceramic, containing:

- 5 (A) 91 to 98.45 wt.-% zirconium oxide,
(B) 0 to 3.5 wt.-% hafnium oxide,
(C) 1.5 to 6.0 wt.-% yttrium oxide,
(D) 0.05 to 0.50 wt.-% of at least one of the oxides of the elements
aluminium, gallium, germanium, indium,
(E) 0 to 1.9 wt.-% coloring additives (calculated as oxides),

10 the wt.-% having to add up to 100 and the blank having a raw breaking
resistance of 15 to 30 MPa.

8. Pre-sintered blank according to claim 7, containing

- 15 (A) 91 to 98.35 wt.-% zirconium oxide,
(B) 0 to 2.5 wt.-% hafnium oxide,
(C) 1.5 to 6.0 wt.-% yttrium oxide,
(D) 0.15 to 0.50 wt.-% of at least one of the oxides of the elements
aluminium, gallium, germanium, indium,
(E) 0 to 1.9 wt.-% coloring additives,

20 the wt.-% having to add up to 100.

9. Pre-sintered blank according to claim 7, containing

- 25 (A) 91 to 98.45 wt.-% zirconium oxide,
(B) 0 to 3.5 wt.-% hafnium oxide,
(C) 1.5 to 6.0 wt.-% yttrium oxide,
(D) 0.05 to 0.50 wt.-% aluminium oxide,
(E) 0 to 1.9 wt.-% coloring additives,

30 the wt.-% having to add up to 100.

10. Pre-sintered blank according to one of claims 7 to 9, having a raw breaking resistance of 25 to 28 MPa.
- 5 11. Pre-sintered blank according to one of claims 7 to 10, obtained by sintering at a temperature of 850°C to 1000°C.
12. Pre-sintered blank according to one of claims 7 to 11, having a deviation from the linearity of the shrinkage per spatial direction below 0.05%.
- 10 13. Use of a blank of pre-sintered material with a raw breaking resistance of 15 to 30 MPa in a process for the preparation of dentures, the blank being processed before the dense sintering.
- 15 14. Process for the preparation of dentures according to one of claims 1 to 5, a blank according to one of claims 7 to 12 being processed by milling into a shrinkage-matched, enlarged model of the end dentures and densely sintered to its end dimensions.
- 20 15. Process for the preparation of dentures according to one of claims 1 to 5, a blank according to one of claims 7 to 12 being processed by CAD/CAM processes to a shrinkage-matched, enlarged model of the end dentures and densely sintered to its end dimensions.
- 25 16. Process according to one of claims 14 or 15, the pre-sintered blank being aesthetically re-processed after the processing and densely sintered to its end dimensions.

Process for the preparation of dentures.

Abstract

5 The invention relates to a process for the preparation of dentures, comprising the steps:

- a) preparation of a blank,
- b) processing of the blank by milling methods,
- c) dense sintering of the blank in a temperature range from 1200 to 1650°C,

the blank comprising a pre-sintered material and having a raw breaking resistance of 15 to 30 MPa.

BIRCH, STEWART, KOLASCH & BIRCH, LLPP.O. Box 747 • Falls Church, Virginia 22040-0747
Telephone: (703) 205-8000 • Facsimile: (703) 205-8050**PLEASE NOTE:
YOU MUST
COMPLETE THE
FOLLOWING****COMBINED DECLARATION AND POWER OF ATTORNEY
FOR PATENT AND DESIGN APPLICATIONS**

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

Insert Title:

PROCESS FOR THE PREPARATION OF DENTURESFill in Appropriate
Information -
For Use Without
Specification
Attached:

the specification of which is attached hereto. If not attached hereto,

the specification was filed on _____ as

United States Application Number _____;

and amended on _____ (if applicable) and/or

the specification was filed on August 16, 2000 as PCTInternational Application Number PCT/EP00/07992;

amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I do not know and do not believe the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representative or assigns more than twelve months (six months for designs) prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows:

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed

Prior Foreign Application(s)**Priority Claimed**Insert Priority
Information:
(if appropriate)199 38 144.5GermanyAugust 16, 1999☒ ☐
Yes No

(Number)

(Country)

(Month/Day/Year Filed)

(Number)

(Country)

(Month/Day/Year Filed)

☐ ☐
Yes No

(Number)

(Country)

(Month/Day/Year Filed)

☐ ☐
Yes No

(Number)

(Country)

(Month/Day/Year Filed)

☐ ☐
Yes No

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional applications(s) listed below.

Insert Provisional
Application(s):
(if appropriate)

(Application Number)

(Filing Date)

(Application Number)

(Filing Date)

All Foreign Applications, if any, for any Patent or Inventor's Certificate Filed More than 12 Months (6 Months for Designs) Prior to the Filing Date of This Application

Country

Application Number

Date of Filing (Month/Day/Year)

Insert Requested
Information:
(if appropriate)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States and/or PCT application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States and/or PCT application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to the patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application

Insert Prior U.S.
Application(s):
(if any)

(Application Number)

(Filing Date)

(Status - patented, pending, abandoned)

(Application Number)

(Filing Date)

(Status - patented, pending, abandoned)

I hereby appoint the practitioners at **CUSTOMER NO. 2292** as my attorneys or agents to prosecute this application and/or an international application based on this application and to transact all business in the United States Patent and Trademark Office connected therewith and in connection with the resulting patent based on instructions received from the entity who first sent the application papers to the practitioners, unless the inventor(s) or assignee provides said practitioners with a written notice to the contrary:

Send Correspondence to:

BIRCH, STEWART, KOLASCH & BIRCH, LLP or **CUSTOMER NO. 2292**

P.O. Box 747 • Falls Church, Virginia 22040-0747

Telephone: (703) 205-8000 • Facsimile: (703) 205-8050

PLEASE NOTE:
YOU MUST
COMPLETE
THE
FOLLOWING:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of First
or Sole Inventor:
Insert Name of
Inventor
Insert Date This
Document is Signed

Insert Residence
Insert Citizenship

Insert Post Office
Address

Full Name of Second
Inventor, if any:
see above

Full Name of Third
Inventor, if any:
see above

Full Name of Fourth
Inventor, if any:
see above

Full Name of Fifth
Inventor, if any:
see above

Full Name of Sixth
Inventor, if any:
see above

GIVEN NAME/FAMILY NAME Sybille FRANK	INVENTOR'S SIGNATURE <i>Sybille Frank</i>	DATE* 20.3.2002
Residence (City, State & Country) Seefeld GERMANY DEX	CITIZENSHIP German	
MAILING ADDRESS (Complete Street Address including City, State & Country) An der Breite 2a, D-82229 Seefeld GERMANY		
GIVEN NAME/FAMILY NAME Holger HAUPTMANN	INVENTOR'S SIGNATURE <i>Holger Hauptmann</i>	DATE* 15.03.2002
Residence (City, State & Country) Sindelsdorf GERMANY DEX	CITIZENSHIP German	
MAILING ADDRESS (Complete Street Address including City, State & Country) Weilbergstrasse 32, D-82404 Sindelsdorf GERMANY		
GIVEN NAME/FAMILY NAME Stefan HÖSCHELER	INVENTOR'S SIGNATURE <i>Stefan Höscheler</i>	DATE* 12/03/2002
Residence (City, State & Country) Seefeld GERMANY Herrsching GERMANY DEX	CITIZENSHIP German	
MAILING ADDRESS (Complete Street Address including City, State & Country) Hedwigstrasse 18, D-82229 Seefeld GERMANY Pilsenseestrasse 9a D-82211 Herrsching GERMANY		
GIVEN NAME/FAMILY NAME Robert SCHNAGL	INVENTOR'S SIGNATURE <i>Robert Schnagl</i>	DATE* 12.03.2002
Residence (City, State & Country) Landsberg GERMANY DEX	CITIZENSHIP German	
MAILING ADDRESS (Complete Street Address including City, State & Country) Von Eichendorff-Strasse 35, D-86899 Landsberg GERMANY		
GIVEN NAME/FAMILY NAME Daniel SUTTOR	INVENTOR'S SIGNATURE <i>Daniel Sutor</i>	DATE* 13.03.02
Residence (City, State & Country) Seefeld GERMANY DEX	CITIZENSHIP German	
MAILING ADDRESS (Complete Street Address including City, State & Country) Hauptstrasse 31, D-82229 Seefeld GERMANY Franz-Kraemer-Strasse 4 D-82229 Seefeld GERMANY		
GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)	CITIZENSHIP	
MAILING ADDRESS (Complete Street Address including City, State & Country)		